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Original Research

Can pregnancy, delivery, and early neonatal complications be predicted using the ultrasonographically measured first trimester placental volume? A prospective study

Prediction of neonatal complications using ultrasonography

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Abstract

Aim: We aimed to determine the relationship between first trimester placental volume and pregnancy, birth, and perinatal complications.

Material and Methods: This prospective observational study was performed between August 2022 and March 2023 at the Department of Obstetrics and Gynecology at Tekirdağ Namık Kemal University Faculty of Medicine. A total of 82 singleton pregnant women at 11 + 0 to 13 + 6 weeks from the last menstrual date or first trimester ultrasonography (USG) were enrolled.

Results: The median age of the patients was 24 (19–35) years. The median placental volume was 22.78 (11.31–35.46) cm3. gestational diabetes mellitus (GDM) developed in nine (11.0%) pregnant women and gestational hypertension (GHT) developed in eight (9.8%). There was a significant positive correlation between the mean placental volume and the maternal weight (r=0.251, p=0.023), gestational age according to the last menstrual period (r=0.572, p<0.001), and gestational age according to USG (r=0.735, p<0.001). There was no significant relationship between the mean placental volume and the birth type (p=0.540), cesarean section indication (p=0.146), admission to the neonatal intensive care unit (ICU) (p=0.733), indication for ICU admission (p=0.520), GDM (p=0.563), and GHT (p=0.527).

Discussion: Although the first trimester placental volume was positively related to maternal weight and gestational age, it was not associated with other variables. However, there is insufficient evidence regarding the role of first trimester placental volume in predicting problems related to pregnancy, delivery, and the early neonatal period.

Keywords

Placental Volume, Ultrasonography, Maternal Weight, Gestational Week, Gestational Diabetes Mellitus

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Introduction

The human placenta is a vascular organ that is a combination of embryo/fetal and maternal tissue, to which the fetus is connected by the umbilical cord. The human placental villi begin to emerge 7 to 8 days after fertilization, and a complete placenta is formed by the 3rd month of pregnancy. The placenta grows gradually as the pregnancy progresses [1, 2]. Transportation and endocrine and metabolic functions of the placenta are the main determinants of fetal nutrition and homeostasis [2-4]. It ensures that oxygen and nutrients are delivered to the fetus and waste products are removed to maintain fetal growth [1]. Adequate blood flow from the placenta is an important determinant of fetal development and maternal health [2]. Considering these factors, placental problems are the primary cause of common pregnancy disorders, including recurrent miscarriages, fetal growth restriction, preeclampsia, and stillbirth [1, 5]. The health, functions, and capacity of the placenta are related to its weight. The placental weight at birth is positively related to the birth weight [6]. Since the 1970s [7], two-dimensional (2D) ultrasonography (USG) has been used to evaluate the placental size during early pregnancy. Several studies have revealed that low placental volume in the first trimester is associated with small for gestational age (SGA) fetus, fetal growth restriction, preeclampsia, gestational diabetes mellitus (GDM), and gestational hypertension (GHT) [8-12]. Problems during pregnancy and the early neonatal period create a serious burden on the health system in addition to negatively affecting maternal and infant health. Detection and prevention of possible complications in early pregnancy are necessary to reduce maternal and fetal mortality and morbidity. Demonstrating that the placental thickness, width, and volume on USG in the first trimester can predict the possible obstetric, fetal, and perinatal risks will provide a proactive approach to managing complications. However, the number of studies on this subject is limited. Thus, we aimed to determine the relationship between first trimester placental volume and pregnancy, birth, and perinatal complications.

Material and Methods

82 participants were included in the study. The sample size of this study was determined based on the study by Soongsatitanon et al [9]. Accordingly, a 95% confidence interval (CI) and 95% power were obtained for a sample calculation of 82 participants. G-Power (version 3.1.9.7) was used to calculate the power of the sample size. This prospective observational study was performed between August 2022 and March 2023 at the Department of Obstetrics and Gynecology at Tekirdag Namık Kemal University.

Measuring the placental volume

Placental volume was measured using a 2D transabdominal USG device (DC-8 Exp; Mindray, Shenzhen, China) and transabdominal convex probe (C5-2s probe; Mindray, Shenzhen, China) in patients during their 11 + 0 to 13 + 6 weeks of gestation, by a single operator blinded to all the clinical data. Volumetric imaging of the placenta was performed with the pregnant woman lying in the semi-recumbent position. After confirming the viability and determining the position of the placenta, optimal probe placement was determined for performing a 2D scan of the entire placenta. This was generally chosen as a cross-sectional plane near the placental center. The width, height, and thickness of the placenta were measured. The mean placental volume was estimated using the following convex–concave shell formula: $V = (\pi T/6) \times [4H(W - T) + W(W - 4T) - 4T2]$, where V = volume; W = maximal width; H = height at maximal height; and T = thickness at maximal height [13]. To calculate the placental volume, it is very important to identify the two ends of the placenta, the width of which is used in the calculation process. Another thing to consider is that the interface of the placenta and decidua is set above the placenta, perpendicular to the width. The thickness was measured along the height line from the junction of the placenta and amniotic fluid to the placental edge.

Other tools and definitions

Preeclampsia and GHT were diagnosed in line with the recommendations of the International Society for the Study of Hypertension in Pregnancy [14]. GDM was diagnosed in accordance with the International Association of Diabetes and Pregnancy Study Groups [15] and the World Health Organization criteria. SGA was defined as a birth weight below the 10th percentile for the gestational age and sex of a standard birth weight curve used in the Turkish population [16]. The APGAR score was assessed using the standard tool [17] at the 1st, 5th, and 10th min after birth. Only the 1st and 5th min APGAR scores were used. The umbilical cord venous blood pH was measured using the blood gas analyzer immediately after childbirth.

Statistical analysis

All statistical analyses were performed using SPSS Statistics for Windows (version 25.0; IBM Corp., Armonk, NY, USA). Conformity of the continuous variables to normal distribution was evaluated using the Kolmogorov–Smirnov test. Non-parametric tests were used to analyze the non-normally distributed data. The Mann–Whitney U test was used to compare two independent groups, and the Kruskal–Wallis test was used to compare more than

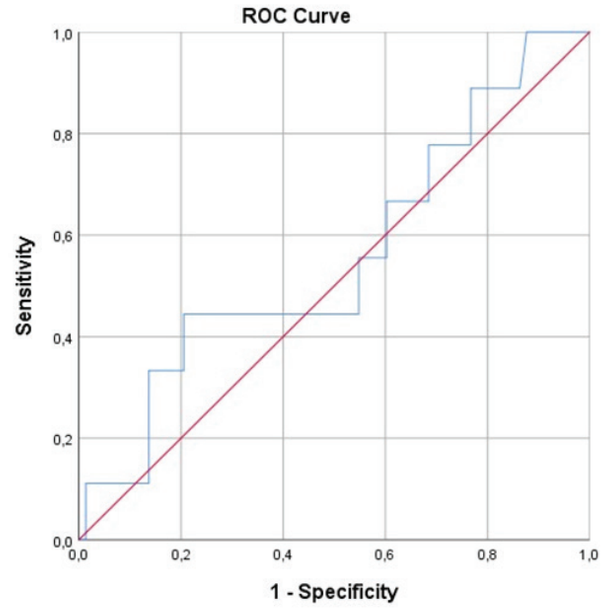

Figure 1. ROC curve graph showing the role of the mean placental volume in predicting the development of gestational diabetes mellitus

two groups. The relationship between the continuous variables was examined using the Spearman correlation test. The role of continuous numerical variables in predicting GDM and GHT was evaluated using the receiver operating characteristic (ROC) analysis. Statistical significance was set at $p < 0.05$.

Ethical Approval

This study was approved by the Ethics Committee of Non-Interventional Clinical Research Ethics Committee of Tekirdag Namık Kemal Unıversity (Date: 2022-07-26, No: 2022.146.07.13).

Table 1. Summary of the maternal, pregnancy, delivery, and newborn characteristics

Variables	Value (n = 82)
Maternal age, years	24 (19–35)
Maternal height, cm	159.25 ± 6.50
Maternal weight, kg	64.5 (50–101)
Maternal body mass index, kg/m^2	26.19 (20.2–38.96)
Gestational week according to the last menstrual period	12.50 (11.29–13.86)
Gestational week measured by USG	12.49 ± 0.63
Mean placental volume, cm^3	22.78 (11.31–35.46)
Gestational diabetes mellitus Present; Absent	9 (11.0%) ; 73 (89.0%)
Gestational hypertension Present; Absent	8 (9.8%); 74 (90.2%)
Type of birth NSVD; C/S	42 (51.2%) ; 40 (48.8%)
Gestational age at birth (week)	39.71 (33.57–41.57)
Baby's birth weight, g	3097.5 (2040–4100)
APGAR at 1 min and 5	8 (5–8); 9 (7–9)
Cord blood pH	7.31 (6.97–7.39)
Admission to the neonatal ICU Yes; No	9 (11.0%) ; 73 (89.0%)
Indication for admission to the neonatal ICU	
Prematurity + RDS	3 (3.7%)
Transient tachypnea of the newborn	3 (3.7%)
Meconium aspiration	1 (1.2%)
Prematurity + SGA + RDS	1 (1.2%)
Respiratory distress	1 (1.2%)

Data are presented as mean ± standard deviation or median (min–max) for continuous variables according to the normality of distribution and as frequency (percentage) for categorical variables.
C/S: Cesarean section, ICU intensive care unit, NSVD: Normal spontaneous vaginal delivery, RDS: Respiratory distress syndrome, SGA: Small for gestational age, USG: Ultrasonography

Table 2. Correlation between the maternal and neonatal characteristics and the mean placental volume

Variables	Mean placental volume (cm^3)	
	r	p
Maternal age, years	−0.119	0.288
Maternal height, cm	0.174	0.117
Maternal weight, kg	0.251	0.023
Maternal body mass index, kg/m^2	0.183	0.099
Gestational week according to the last menstrual period	0.572	<0.001
Gestational week measured by to USG	0.735	<0.001
Gestational age at birth	−0.064	0.566
Baby's birth weight, g	0.024	0.833
APGAR 1.min	0.034	0.760
APGAR 5.min	0.034	0.759
Cord blood pH	−0.006	0.958

r: Spearman correlation coefficient, USG: Ultrasonography

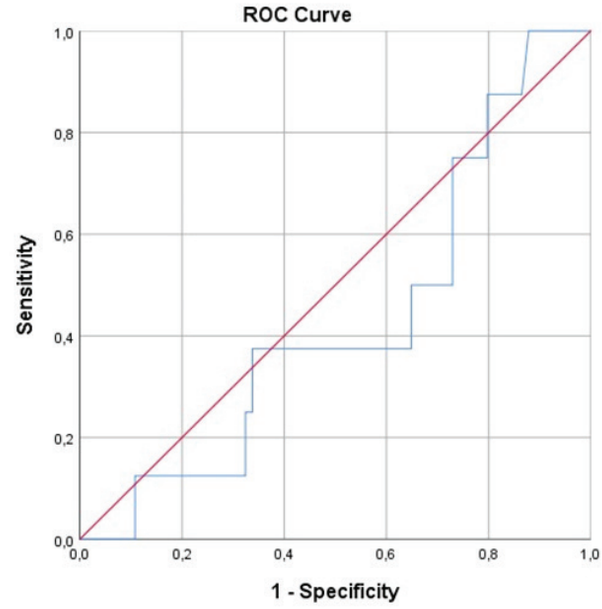

Figure 2. ROC curve graph showing the role of the placental volume in predicting the development of gestational hypertension.

Table 3. Distribution of the mean placental volume by delivery type, indication for cesarean section, admission to the intensive care unit, and the presence of gestational diabetes mellitus and hypertension

Variables	Mean placental volume (cm^3)	p
Birth type		
C/S	21.33 (12.07–35.46)	0.540
NSVD	23.09 (11.31–34.23)	
C/S indication		
Cephalopelvic disproportion/incompatibility	25.37 (18.87–33.60)	0.146
Fetal distress	22.78 (12.09–32.96)	
Macrosomia	31.16 (31.16–31.16)	
Malpresentation	18.83 (13.22–29.33)	
Preeclampsia	19.63 (13.22–31.97)	
Placenta previa	32.41 (29.37–35.46)	
Prolonged labor	16.26 (12.07–29.08)	
Admission to the neonatal ICU		
Yes	22.27 (12.63–32.96)	0.733
No	22.81 (11.31–35.46)	
Indication for admission to the neonatal ICU		
Meconium aspiration	12.63 (12.63–12.63)	0.520
Prematurity + RDS	17.71 (13.22–27.09)	
Prematurity + SGA + RDS	26.44 (26.44–26.44)	
Respiratory distress	22.27 (22.27–22.27)	
Transient tachypnea of the newborn	25.06 (20.58–32.96)	
Gestational diabetes mellitus		
Present	22.27 (13.22–34.23)	0.563
Absent	22.81 (11.31–35.46)	
Gestational hypertension		
Present	19.63 (13.22–31.97)	0.527
Absent	22.82 (11.31–35.46)	

Data are expressed as median (min–max)
C/S: Cesarean section, ICU intensive care unit, NSVD: Normal spontaneous vaginal delivery, RDS: Respiratory distress syndrome, SGA: Small for gestational age, ICU intensive care unit

Results

The median age of the patients was 24 (19–35) years. The median gestational age according to the last menstrual period was 26.19 (20.2–38.96) weeks while it was 12.49 ± 0.63 weeks according to USG. The median placental volume was 22.78 (11.31–35.46) cm3. GDM developed in nine (11.0%) pregnant women and GHT developed in eight (9.8%). Forty (48.8%) pregnant women delivered by C/S due to fetal distress (n = 10) or prolonged delivery (n = 10). Nine (11.0%) newborns were admitted to the ICU, and the most common indications were prematurity with respiratory distress syndrome (n = 3) and transient tachypnea (n = 3). All variables related to the pregnancies, births, and newborns and are summarized in Table 1. There was no significant relationship between the mean placental volume and the birth type (p = 0.540), C/S indication (p = 0.146), admission to the neonatal ICU (p = 0.733), indication for ICU admission (p = 0.520), GDM (p = 0.563), and GHT (p = 0.527) (Table 3). There was a significant positive correlation between the mean placental volume and the maternal weight (r = 0.251, p = 0.023), gestational age according to the last menstrual period (r = 0.572, p < 0.001), and gestational age according to USG (r = 0.735, p < 0.001) (Table 2). ROC analysis evaluating the success of the first trimester mean placental volume in predicting the development of GDM and GHT is presented in Table 3, Figure 1 and Figure 2. The mean placental volume measured in the first trimester could not significantly predict the occurrence of GDM [AUC (95% CI) = 0.559 (0.351–0.767), p = 0.568)] and GHT [AUC (95% CI) = 0.432 (0.239–0.626), p = 0.532)].

Discussion

We found that the first trimester placental volume was significantly associated with the maternal body weight and gestational age at the time of volume measurement. There was no significant relationship between the first trimester placental volume and the other variables examined in the study. Obesity is becoming a common problem among pregnant women worldwide and is associated with a number of placenta-mediated obstetric complications such as preeclampsia, macrosomia, intrauterine growth restriction, and stillbirth. In addition to these direct effects, obesity can negatively and indirectly affect the placental health, pregnancy, and birth process by increasing the risk of GDM [20]. The placenta has a key role in programming intrauterine development. Therefore, it is important to know the effects of maternal obesity on placental development. In the present study, a weak, significant, positive correlation was found between the first trimester placental volume and the maternal weight. We found a statistically significant positive correlation between the maternal BMI and body weight, and the fetal and placental weight. Howell and Powell showed that increased levels of maternal adipokine and metabolic hormones associated with body weight can cause an increase in the placental size and function and have long-term metabolic and behavioral consequences on the newborns [19].

We found that placental volume and weight increase as the gestational age increases; this has been reported in previous studies as well [11, 21]. Our study results confirmed that the first trimester gestational age and placental volume were positively correlated. Pala et al. reported that placental volume was statistically significantly positively correlated with gestational age (r = 0.219) and parity (r = 0.228) [11]. Similarly, in another study, there was a similar and significant relationship between gestational age and placental volume [21]. The placental volume increases as the pregnancy progresses because the fetus grows, which in turn increases the transfer of necessary oxygen, nutrients and other important components. Under hormonal influence, the placental volume increases in the later weeks of pregnancy. Thus, the placental volume is expected to increase as the gestational age increases. Furthermore, this volume increase is necessary for the healthy growth of the baby. However, if the increase in placental volume is more or less than it should be, it can cause problems in the growth or health of the fetus. Although the first trimester placental volume did not significantly affect the pregnancy process and outcomes in our study, ensuring the standardization of placental volume and volume increases according to the gestational age, following up women to assess this, and investigating the cause of possible adverse events can contribute to better pregnancy management and outcomes.

One of the main aims of this study was to evaluate the efficacy of first trimester placental volume in predicting the occurrence of GDB and GHT. However, there was no significant relationship between the first trimester placental volume and the development of GDB and GCT. The increased risk of greater fetal birth weight in pregnant women with GDM also carries the risk of increased placental weight [22]. It is believed that this situation may be an indicator of increased delivery of nutrients to the placenta or a direct effect of GDM independently increasing both fetal and placental growth [22]. Results obtained from previous studies using 2D and three-dimensional (3D) USG show that there is no placental growth in the first trimester in pregnant women with GDM; placental growth occurs in the second trimester and later in pregnant women with GDM [10-12]. Wong et al. suggested that placental overgrowth is not evident in pregnant women with GDM due to the limited-term effect of hyperglycemia in the first trimester; however, this effect emerges as pregnancy progresses when the continuous effect of hyperglycemia is seen [12]. They also stated that the high glucose level in the placenta of patients with GDM may cause an increase in the glycogen, DNA, and lipid content in the placenta. While some studies have reported that the first trimester placental volumes in women with GHT are smaller than that in women without GHT [8, 9, 23], others have reported that they are larger [23], and some have stated that there is no significant difference [24]. Our study results also showed that there was insufficient evidence to use first trimester placental volume measurements in predicting the occurrence of GHT and GDM in the later stages of pregnancy.

Evaluation of the placenta via USG makes important contributions, because of its advantages such as ease of application, absence of side effects, and cost-effectiveness. In the present study, we evaluated the relationship between additional parameters, such as the newborn APGAR score, neonatal ICU requirement, gestational age, umbilical cord blood pH, and delivery type, and the first trimester placental volume, which has never been investigated before to the best of our

knowledge. However, no significant relationship was found between any of these variables and the first trimester placental volume. The role of first trimester placental volume, measured via USG, in predicting pregnancy problems in the following trimesters, problems related to delivery, and problems in the early neonatal period seems to be limited or unclear.

Limitation

The current study has some limitations. Since our study was conducted at a single center with relatively few participants, the generalizability of its results is limited. Since the incidence of pregnancy complications such as GHT and GDM is relatively low, the relationship with the first trimester placental volume may not have been shown statistically. The main purpose of our study was to identify a parameter that can predict problems that may occur in the later stages of pregnancy and at birth. Therefore, placental volumes in the second and third trimesters, temporal changes in the placental volume, and the effects of these changes on the results were not investigated. Hence, there is a need for future studies that include case groups with and without relevant gestational complications and with a larger sample population, where placental volumes are evaluated not only in the first trimester, but also in the second and third trimesters.

Conclusion

In conclusion, although the first trimester placental volume was positively related to maternal weight and gestational age, it was not associated with maternal age, maternal height, maternal BMI, GDM, GHT, birth type, C/S indication, gestational age at birth baby's birth weight, APGAR scores at 1 min and 5 min, cord blood pH, admission to the neonatal ICU, and indication for admission to the neonatal ICU. However, there is insufficient evidence regarding the role of first trimester placental volume in predicting problems related to pregnancy, delivery, and the early neonatal period. Thus, more comprehensive studies are required to investigate this.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or compareable ethical standards.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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